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DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

# MINING AND GRINDING METHODS AND COSTS AT THE L. W. CAMP CO. SHALE PIT, AKRON, OHIO

BY

E. J. LINTNER

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# MINING AND GRINDING METHODS AND COSTS AT THE L. W. CAMP CO. SHALE PIT, AKRON, OHIO 1/

By E. J. Lintner2/

## INTRODUCTION

This paper is one of a series being prepared by the United States Bureau of Mines describing clay mining and crushing methods and costs at various operations throughout the United States. These papers are designed to disseminate technical information regarding methods used. The cost tabulations represent local operating expenditures only and not total production costs. It is recognized that publication of total production costs might, in many instances, cause embarrassment to the individual operator as well as to the industry as a whole. On the other hand, operating costs are essential to a technical discussion and study of the methods employed. The attention of the reader is specifically called to this differentiation in order that no misunderstanding of the scope of the cost tabulations may ensue.

The author wishes to acknowledge the assistance of the following persons: L. W. Camp, general manager; S. Cooper, plant superintendent; and W. R. Riel, office manager.

## HISTORICAL

Akron and Summit Counties long have been prominent producers of ceramic products. It was here that such pioneering events took place in the industry as formerly to rank this section near the top of the industry in the entire country.

In the city of Akron, the clay industry was initiated by Edwin H. Merrill and his brother, Calvin J. Merrill, in 1835. At first they manufactured stoneware. A little later bottles and clay smoking pipes were produced. Still later they produced a stoneware pump that was successful and attained considerable popularity in those early days. The smoking-pipe

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2/ Associate mining engineer, U.S. Bureau of Mines.



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industry developed rapidly and flourished for about fifty years. The original mold for making these pipes was cut with a chisel, by hand, from a solid piece of steel by Calvin J. Merrill. This was said to have been the beginning of the use of steel dies in the making of any kind of a clay product.3/

In 1842 Julius Sumner began manufacturing stoneware. His plant operated for over half a century.

In 1849 Col. Reuben McMillen, David E. Hill, and Robert Foster formed a company under the name of Hill, Foster, & Co. In 1851 the Merrill Bros. and Hezekiah Camp bought out Mr. Foster. The firm now became known as Hill, Merrill, & Co. In 1853 David Hill and Calvin Merrill developed a machine for making sewer pipe. This plant was the first of its kind west of New York and the second in the United States to manufacture sewer pipe.4/

In 1861 E. H. and H. E. Merrill established the Akron Pottery. In 1879 Robinson Bros. organized a company to manufacture sewer pipe. These two companies soon were merged and later became the nucleus for the Robinson Clay Products Co. of today.

In 1866, J. Park Alexander established the first fire-brick plant in northern Ohio. It was known as the Diamond Fire-Brick Works. The yearly production amounted to 1,000,000 brick. In 1873, the Akron Fire-Brick Co. was formed by Byron M. Allison and Delos Hart.

In 1868, the Hill & Adams Sewer Pipe Co. was formed. In this same year, Mr. Hill and Ozias Barber invented the first steam press used to make sewer pipe.5/ This invention proved a great impulse to the growing sewer-pipe industry in Ohio.

In 1875 Horace B. Camp entered upon the manufacture of roofing tile at Cuyahoga Falls. After a short while he sold his interests to J. E. Ewart of Akron. He immediately took up the work with much faith and energy and has unquestionably done as much or more than any other man to promote the use of roofing tile in the United States. The plant he erected at Akron in the late seventies was continually enlarged and for many years held the record of being the largest and virtually the only successful plant of its kind in the country.6/

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3/ Lane, Samuel A., Fifty Years and Over in Akron and Summit County: Beacon Job Department, Akron, Ohio, 1891, p. 475.

4/ Olin, O. E., Akron and Environs: Lewis Publishing Co., Chicago, Ill. 1917, p. 259.

5/ Stout, Wilbur, Stull, R. T., McCaughey, Wm. J., and Demorest, D. J., Coal Formation Clays of Ohio. Geol. Survey of Ohio, Bulletin 26, 1923, p. 37.

6/ Worcester, W. G., Geological Survey of Ohio: 4th ser., Bull. 11, 1910, p. 13.



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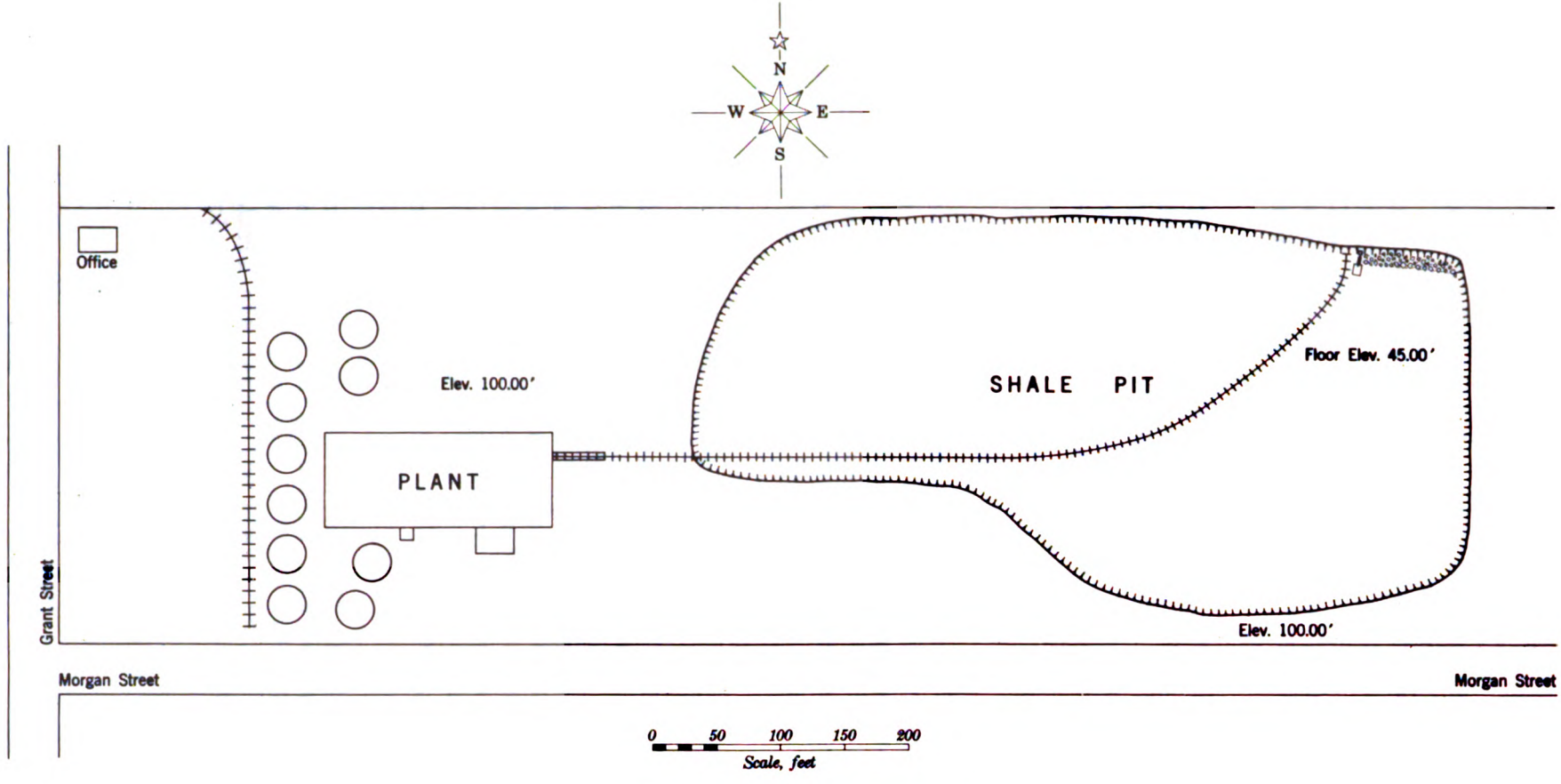


Figure 1.—Plant layout, L. W. Camp Company, Akron, Ohio.

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In 1882, Weeks, Cook, and Weeks built a plant to manufacture stoneware. It was purchased in 1906 by Maurice A. Knight and now bears his name. Today this company is said to be the only one in the United States devoted exclusively to the manufacture of acid-proof chemical stoneware, and it is known throughout the world. The products manufactured are all specially designed articles made to order. They are shipped to all parts of the globe. The clays now used, however, are all purchased from various outside fields and blended.

In 1884, Samuel C. Dyke of Akron began the manufacture of toy jugs. The demand became so great that within 3 years about 30,000 were turned out daily. Later he began the manufacture of marbles. For a long time the only pottery in the country devoted exclusively to the manufacture of marbles was located in Akron. This industry was conceived and developed by J. F. Brown.

In 1891, the Akron Paving Brick Co. was organized to manufacture paving brick.

In 1902, L. W. Camp organized the company that bears his name. He secured a tract of land in the city of Akron adjoining Grant and Morgan Streets, opened a pit, erected a modern plant, and commenced the manufacture of hollow building tile. A short while later, the manufacture of brick was begun. (fig. 1.) The plant is served by the Akron and Barberton Belt Railway, connecting with the Pennsylvania, Baltimore & Ohio, Erie, and the Akron, Canton & Youngstown Railroads.

## GEOLOGY

The shale now mined in Akron and vicinity occurs in the Pottsville Formation of the Pennsylvania System.. This is the lowest of four formations of this system. It is of great importance to the ceramic industry as it contains not only several beds of very valuable shale and clay but also the necessary fuel for the burning of the ceramic products manufactured. It extends over the greater part of twenty-four counties of the State, reaching from the most southerly point of the State northeastwardly towards Lake Erie, east of Cleveland. The clay in some of these counties, however, is of little value. The formation varies from 175 to 400 feet in thickness, averaging about 255 feet.

The Pottsville formation is composed of a series of beds of shale, clay, sandstone, limestone, coal, and iron ore. The names by which the clays and shales are known are usually the same as those given to the overlying coals. Those mined in Akron are termed the Massillon and the Anthony shales. They are siliceous and plastic and have a medium fine texture, and their color ranges from light to dark gray.

An exposed section in the open pit is as follows:

| | |
|---|---|
| Overburden -------- | 8 to 10 feet |
| Sandstone -------- | 10 to 12 feet |
| Bluish gray shales- | 30 to 40 feet |



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The bed of sandstone is present only in the northeast corner of the pit, and it gradually thins out and disappears entirely 300 feet to the west. The face having been badly weathered, it was difficult to distinguish any dividing line between the shales.

As stated above, the Pottsville formation averages 255 feet in thickness. Just how thick it is in this immediate locality is not definitely known. However, the shales do extend below the floor of the pit. (See p. 5, Miscellaneous Drilling.)

## MINING METHODS

### Stripping

The overburden is a yellowish brown clay of very good quality. It is not discarded but is shot down and loaded along with the shales, so that a fairly uniform mix results.

### Drilling

All drilling is done with a churn drill on contract for $0.50 per foot. A 6-inch hole usually is drilled through the overburden and cased. Then a 4-inch hole is drilled to the desired depth. The holes are generally placed 20 feet from the face and from 20 to 30 feet apart. As a rule, only one hole is drilled and shot at a time.

### Blasting

A 50-foot hole is loaded as follows: First, a pocket is made in the bottom of the hole with about 50 pounds of 40 percent gelatin dynamite, size 1-1/2 x 8 inches. Then, a charge of from 50 to 100 pounds of 40-percent gelatin dynamite is placed in this pocket, together with a no. 6 electric detonator. Next, about 12 feet of clay stemming is added and then about 75 pounds of FF-"B" blasting powder. A no. 6 first-delay electric detonator is inserted in a stick of dynamite and placed in this charge. Again, about 10 feet of clay stemming is added. Next comes about 75 pounds of the same black powder and a no. 6 second-delay electric detonator in a stick of dynamite. Clay stemming is then added to fill the hole. The charges are now connected in series and fired by means of a blasting machine of the rack-bar type. The black powder is used because, after exhaustive tests, it proved best for these shales. It produces the desired shattering effect without scattering the material. The loading and firing are always handled by the plant superintendent personally. Each hole breaks 1,800 to 2,000 tons.

### Loading

A 5/8-cubic yard caterpillar shovel is used to load the shattered material into one car of 2-1/2 cubic yards capacity. Motive power is supplied by a 4-cylinder, 45-horsepower, gasoline motor. Usually three dippers provide a full load. However, a fourth generally is added, producing a heaping load. The angle of loading is generally 140 degrees. It usually requires 2-1/2 minutes to load a car at this angle.



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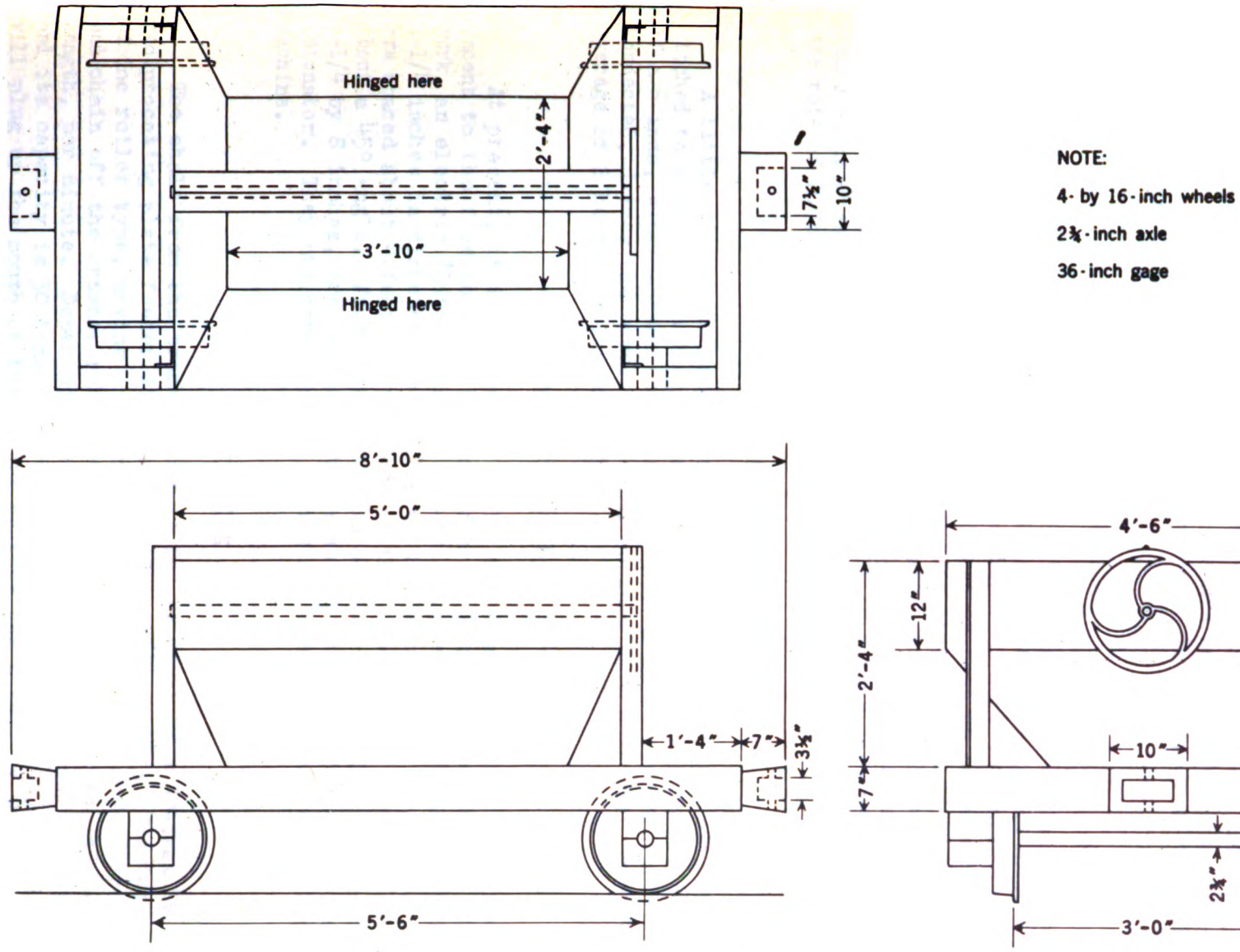


Figure 2.—Sketch of 2½-cubic yard drop-bottom mine car.

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The loading is rapid, as there are very few large chunks to cause any serious delays. This allows the shovel operator plenty of time between trips to maneuver his shovel, shift the track, trim the face, and perform any other odd jobs that may arise. The shovel consumes about 10 gallons of gasoline during an 8-hour shift, loading an average of 100 tons, or at the rate of 0.1 gallon per ton.

## Transportation

A 4-ton, 36-inch gage, 4-cylinder, 33-horsepower gasoline locomotive is used to pull a single 2-1/2-cubic yard drop-bottom car to the crushing plant (fig. 2). An adverse 10-percent grade about 300 feet in length from the open pit floor to the hopper above the crusher must be negotiated. The car is pulled over a small, rectangular, wooden-track hopper of 3-car capacity and dumped by hand. The locomotive engineer dumps the shale and raises the car bottom back into place. In all, it takes about 9 minutes to make a return trip of approximately 1,100 feet. In an 8 hour day the locomotive consumes about 6 gallons of gasoline, hauling an average of 100 tons, or at the rate of 0.06 gallon per ton.

## Drainage

A little seepage is encountered along the floor of the pit. This is ditched to a small sump in the north side of the pit, and pumped out by means of a 6-inch, single-stage, centrifugal pump. A 15-horsepower motor, direct-connected, drives the pump. In normal weather this unit will operate on an average of 2 hours per day of 24 hours.

## Miscellaneous Drilling

At present, it is planned to drill and shoot a little of the floor adjacent to the face so as to have a higher working face eventually. For this work, an electric "Little Giant", 440-volt, auger drill is used. Holes 1-1/4 inches in diameter are drilled to depths of from 3 to 9 feet. These are spaced about 4 feet apart. Some of them are drilled vertical, others at about a 45° angle. From 2 to 10 sticks of 40-percent gelatin dynamite, size 1-1/4 by 8 inches, are loaded in these holes, together with a no. 6 electric detonator. They are connected in series and fired by means of a blasting machine.

## Crushing

The shale from the track hopper is fed by means of a 30-inch by 6-foot reciprocating plate feeder directly into the roll crusher. The feeder is of the roller type, moving on four 8-inch wheels. It is driven by a sprocket and chain off the crusher roll shaft at a speed of 8 strokes, of 3-inch length, per minute. Depth of material on the plate is usually 28 inches, and its capacity is 30 tons per hour. Occasionally, large pieces of shale will plug up the mouth of the feeder so that the attendant must spend a considerable part of his time in this vicinity.



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The single roll on the crusher is 20 inches in diameter, having 3 by 3-inch teeth. Its capacity is 35 tons per hour. The roll speed is 44 r.p.m. and its peripheral speed 230 feet per minute. The maximum size of the product delivered is 6 inches.

## Grinding

A 16-inch by 15-foot conveyor belt, inclined upward at 5 degrees from the horizontal and traveling over 16-inch-diameter pulleys, moves the crushed shale directly into the dry pan. This belt has a capacity, at a speed of 165 feet per minute, of 65 tons per hour. It is driven by an 8-inch rubber belt off the horizontal shaft of the dry pan.

The diameter of the dry pan is 9 feet. The pan is mounted on an 8-inch-diameter vertical shaft and travels at 36 r.p.m. It is driven by a 49-inch-diameter, 12-1/2-inch fact, friction-clutch pulley mounted on the horizontal shaft, traveling at a speed of 150 r.p.m. Its capacity is 30 tons per hour. This unit is driven through a 12-inch rubber belt off the main line shaft. The life of the screen plates is 4 to 8 months.

When ground to sufficient fineness, the shale passes through the 3/16-inch slots in the screen plates and out of the pan into a 16-inch by 50-foot belt elevator. This unit has 14 by 6-inch buckets spaced 10-1/2 inches apart. The drive pulley is 28 inches in diameter with an 18-inch face. Its capacity, at a speed of 235 feet per minute, is 80 tons per hour. This elevator lifts the shale to the top of the building, where it is discharged over an enclosed electric vibrating screen size 4 by 5 feet. This is inclined at an angle of 40 degrees from the horizontal. The size of the opening in the screen is 0.1250 by 0.3750 inch, with the longer dimension lying at right angles to the flow of material. The product passing over the screen is returned by gravity through a 10-inch-diameter spout to the dry pan on the floor below. The product passing through the screen falls upon a 16-inch by 40-foot rubber conveyor belt, by which it is taken to the finished storage bin. This conveyor belt is inclined upward at an angle of 10 degrees from the horizontal. It runs over 18-inch-diameter pulleys at a speed of 280 feet per minute. Its capacity at this speed is 124 tons per hour.

The finished storage bin is made of 2 by 4's, side construction, about 7 by 12 by 12 feet, and holds approximately 38 tons of the finely ground shale. This bin is located immediately above the pug mill so that the shale is fed directly into this machine through a simple slide gate, the maximum opening of which is 20 by 20 inches. An opening of 3 inches usually will insure a sufficient flow of material for continuous operation of the pug mill.

Figure 3 is a typical flow sheet of this operation.

Power for all this equipment, the pug mill included, is obtained from a 6-inch-diameter main-line shaft traveling at 120 r.p.m. This is driven by a 200-horsepower, A. C., 3-phase, 60-cycle, 440-volt motor traveling at 580 r.p.m. A short-center belt drive is used. The drive pulley is 12 inches in diameter, the driven pulley is 8 feet in diameter, both having a 26-inch face with 10-foot centers.



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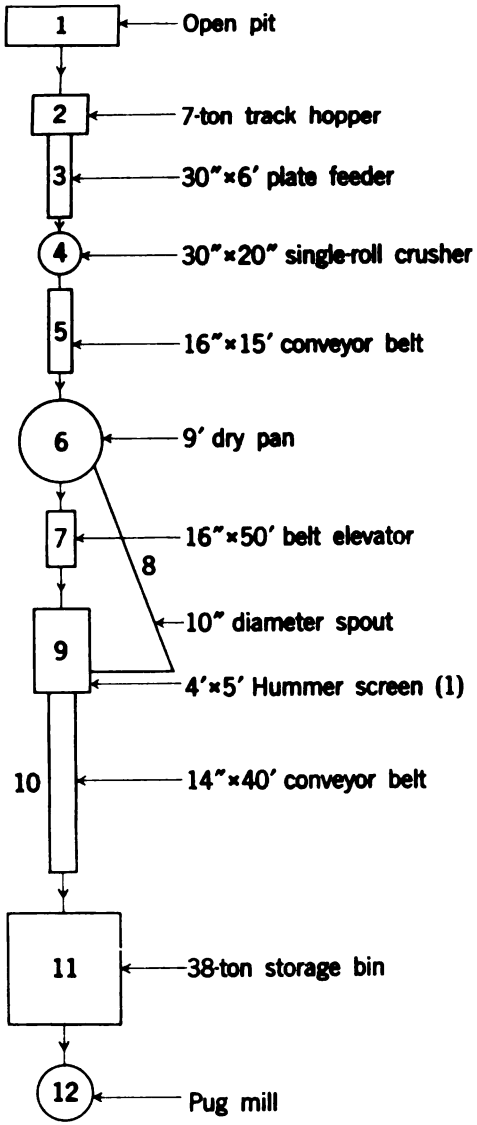


Figure 3.—Flow sheet.

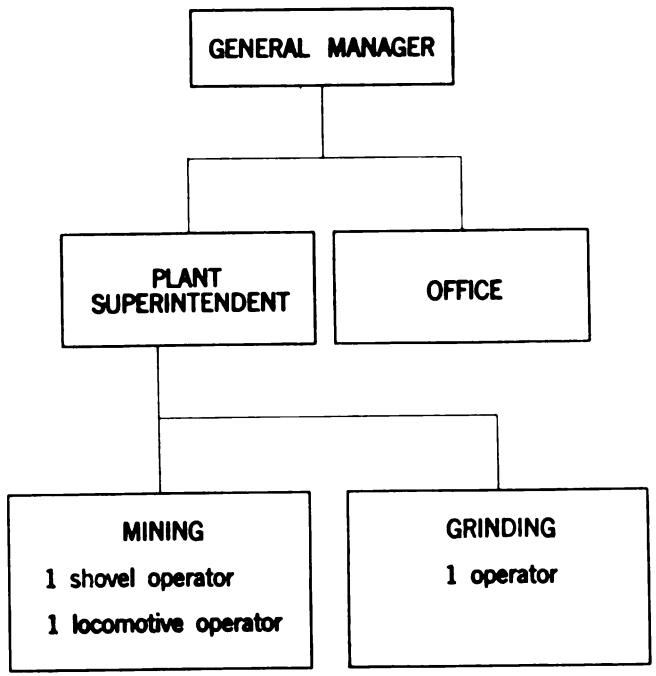


Figure 4.—Organization chart.

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To obtain alternating current for the vibrating screen, an 8-horsepower, 3-phase, 60-cycle, 42-ampere, 440-volt motor running at 1,750 r.p.m. is connected by three "V"-belt drives on 26" centers to an A. C. generator of 110 volts, 18.2 amperes, and 2 kv.-a. capacity. This unit is located on the ground floor in the machine room.

## Electric Power

All electricity, 440 volts, is purchased from the Ohio Edison Co. The rate averages $0.03 per kw.-hr.

## Percent Extraction

Of the thickness mined, a 100-percent extraction is obtained, both the overburden and sandstone being used together with the shale. As no prospecting and exploration work have been done, it is not known just how thick the Pottsville formation is in this immediate locality.

## EMPLOYEE PAY SYSTEM

The hourly rate of pay is used here. At present, the rates are as follows:

| Classification | Number of Men | Hourly Rate | Hours per Day |
|---|---|---|---|
| Shovel Operator | 1 | $0.45 | 8 |
| Locomotive Operator | 1 | .40 | 8 |
| Crushing Operator | 1 | .50 | 8 |

At present 8 hours comprise a working day. In normal times the pit operates approximately 300 days per year and produces an average of 100 tons per 10-hour day.

## FORM OF ADMINISTRATIVE ORGANIZATION

Figure 4 is an organization chart showing proper distribution of authority.



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## I. - SUMMARY OF COSTS

Name: L. W. CAMP CO., AKRON, OHIO. Period covered: 1930.

Total material loaded during period: SHALE, 28,300 TONS (2,000 Lb.).

Operating Costs Per Dry Ton Shale Mined

| | 1 Labor | 2 Super-vision | 3 Air drills, steel | 4 Power cost | 5 Fuel cost | 6 Explo-sives cost | 7 Other supplies | 8 Total |
|---|---|---|---|---|---|---|---|---|
| Mining(per ton): | | | | | | | | |
| Drilling ..... | $0.0141 | --- | $0.0004 | $0.0001 | --- | --- | --- | $0.0146 |
| Blasting ..... | .0010 | --- | --- | --- | --- | $0.0071 | --- | .0081 |
| Loading ..... | .0805 | --- | --- | --- | $0.0164 | --- | $0.0341 | .1310 |
| Transportation | .0517 | --- | --- | --- | .0097 | --- | .0084 | .0698 |
| Miscellaneous. | .0118 | $0.0237 | --- | .0023 | --- | --- | .0017 | .0395 |
| Crushing ..... | .0198 | --- | --- | .0343 | --- | --- | .0010 | .0551 |
| Grinding ..... | .0213 | --- | --- | .0570 | --- | --- | .0289 | .1072 |
| Screening ..... | .0058 | --- | --- | .0069 | --- | --- | .0017 | .0144 |
| Elevating ..... | .0057 | --- | --- | .0141 | --- | --- | .0016 | .0214 |
| Conveying ..... | .0048 | --- | --- | .0071 | --- | --- | .0009 | .0128 |
| Miscellaneous plant ..... | --- | .0268 | --- | --- | --- | --- | --- | .0268 |
| Total cost .... | .2163 | .0505 | .0004 | .1220 | .0261 | .0071 | .0783 | .5007 |



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## II. - SUMMARY OF COSTS IN UNITS OF LABOR, POWER, AND SUPPLIES

Name: L. W. CAMP CO., AKRON, OHIO. Period Covered: 1930.

Material loaded during period: SHALE 28,300 TONS., WT. PER CU. YD. LOOSE MEASURE 2,280 LB.

| | Mining | Crushing | Other | Total |
|---|---|---|---|---|
| A. Labor (man-hours per ton of shale): | | | | |
| Drilling | 0.0093 | --- | --- | 0.0093 |
| Blasting | .0031 | --- | --- | .0031 |
| Loading | .0973 | --- | --- | .0973 |
| Haulage | .0973 | --- | --- | .0973 |
| Miscellaneous | .0486 | --- | 0.9730 | .1459 |
| Supervision | .0177 | 0.0107 | .0107 | .0391 |
| Total labor | .2733 | .0107 | .1187 | .3920 |
| Av. tons per man-shift | --- | --- | --- | 33.33 |
| Labor, percent of total cost | --- | --- | --- | 43.26 |
| B. Power and supplies: | | | | |
| Explosives (lb. per ton) | .0410 | --- | --- | .0410 |
| Total power (kw.-hr. or hp.-hr. per ton) - | | | | |
| 1. Shovels --- hp. | 2.8900 | --- | --- | 2.8900 |
| 2. Locomotives-do. | 1.5710 | --- | --- | 1.5710 |
| 3. Pumping --- kw.-hr. | .0766 | --- | --- | .0766 |
| 4. Crushing -- do. | --- | 1.1433 | --- | 1.1433 |
| 5. Grinding -- do. | --- | --- | 1.9000 | 1.9000 |
| 6. Screening - do. | --- | --- | .2300 | .2300 |
| 7. Elevating - do. | --- | --- | .4700 | .4700 |
| 8. Conveying - do. | --- | --- | .2333 | .2333 |
| Other supplies in percent of total sup. | --- | --- | --- | 33.47 |
| Supplies and power cost, percent of total cost | --- | --- | --- | 56.74 |



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## III. - DETAILED AVERAGE SHOVEL COSTS, DIRECT OPERATION

Name: L. W. CAMP CO., AKRON, OHIO. Period Covered: 1930

Type of shovel: GASOLINE - CATERPILLAR.

Tons of shale loaded: 28,300

| | Amount | Cost per ton |
|---|---|---|
| Shovel operation: | | |
| Engineer | $2,200.00 | $0.0778 |
| Fuel or power | 462.50 | .0164 |
| Grease & lubricants | 10.00 | .0004 |
| Other operating supplies | 50.00 | .0017 |
| Total supplies | 522.50 | .0185 |
| Shovel repair labor | 75.00 | .0026 |
| Repair supplies | 905.95 | .0321 |
| Total repairs | 980.95 | .0347 |
| Total shovel operation | 3,703.45 | .1310 |

## IV. - DETAILED SUMMARY COSTS - DIRECT OPERATION - SHALE PIT

Name: L. W. CAMP CO., AKRON, OHIO Period Covered: 1930.

| | Amount | Cost per ton |
|---|---|---|
| Loading all shovels | $3,703.45 | $0.1310 |
| Drilling: | | |
| Operating labor | 400.00 | .0141 |
| Air, gas, power | 10.00 | .0004 |
| Operating supplies | 5.00 | .0001 |
| Repair labor | --- | --- |
| Repair supplies | --- | --- |
| Total drilling | 415.00 | .0146 |
| Blasting: | | |
| Labor | 28.80 | .0010 |
| Explosives | 201.78 | .0071 |
| Other supplies | --- | --- |
| Total blasting | 230.58 | .0081 |
| Haulage: | | |
| Locomotive | 1,854.75 | .0654 |
| Cars | 20.00 | .0007 |
| Trace maintenance | 105.00 | .0037 |
| Dump maintenance | --- | --- |
| Total haulage | 1,979.75 | .0698 |
| General charges | 1,118.80 | .0395 |
| Grand total | 7,447.58 | .2630 |



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